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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XLVI. April 9, 1886. No. 6

J. W. L. Glaisher, M.A., F.R.S., President, in the Chair.

W. H. S. Monck, M.A., 13, Belvedere Place, Dublin,

was balloted for and duly elected a Fellow of the Society.

On some suggested Improvements in the Practical Working of M. Loewy's New Method of Determining the Elements of Astronomical Refraction. By David Gill, LL.D., F.R.S., Her Majesty's Astronomer at the Cape of Good Hope.

The progressive requirements of exact astronomy have, for a long time, demanded in vain a direct, simple, and practical method for determining the elements of refraction.

The method proposed (*Comptes Rendus*, tome cii. p. 74) appears at last to indicate the means by which such a determination can be made with all desirable accuracy, and the author, M. Loewy, deserves the congratulations, as well as the thanks, of astronomers for the powerful, elegant, and simple method which he has suggested.

M. Loewy proposes to place a prism having two silvered reflecting surfaces inclined to each other at 45° in front of the object-glass of a telescope. The prism is mounted symmetrically with respect to the optical axis of the telescope; the line of the intersecting reflecting planes being next the object-glass, and capable of rotation in a plane at right-angles to the axis of the telescope.

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The arrangement is shown in the accompanying fig. 1 :—

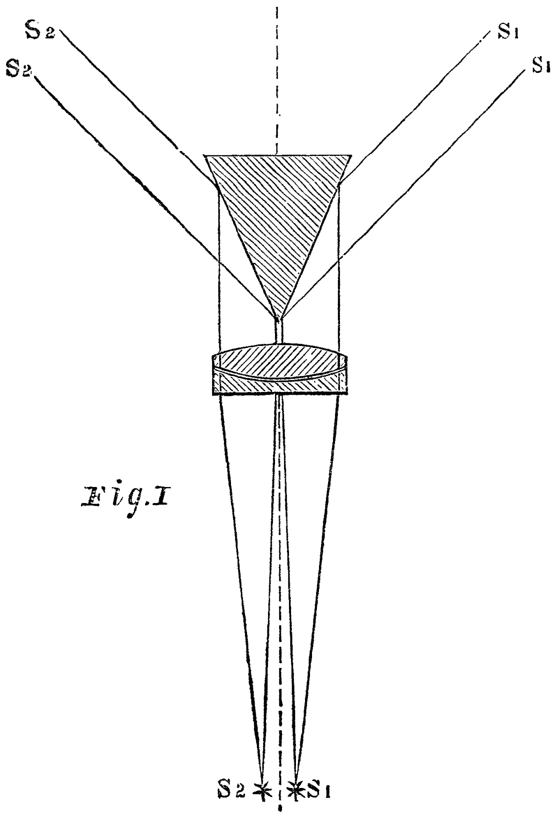

Fig. I

The figure represents the path of the rays from stars S_1 and S_2, where the angle between the stars is slightly greater than twice the angle of intersection of the reflecting planes of the prism.

The apparatus is mounted as an ordinary equatorial telescope. In this way any two stars in the heavens which are 90° on the great circle apart ± (the diameter of the field of view) can be seen simultaneously in the field when the axis of the telescope is directed to the middle point between the stars, and the prism is turned so that the line of intersection of its reflecting planes is at right-angles to the great circle joining the stars. The distance between the images of the stars in the field of view will vary in consequence of the changes of refraction due to the change of altitude produced by the diurnal motion. The apparent angle between the stars themselves will be a maximum when both stars have the same altitude, and a minimum when one is on the horizon and the other at the zenith.*

If a spider-line micrometer is attached to the eye-end of the telescope so that its direction of measurement is at right-angles

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* The angle between the images in the field of view will follow the same law when the angle between the stars is greater than twice the angle of the prism, but will be reversed when the angle between the stars is less than twice the angle of the prism.

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to the line of intersection of the reflecting planes of the prism, then this micrometer will measure the true change of the distance between the stars (that is, the variation of the effect of refraction) entirely independent of any small changes in the position of the prism with respect to the axis of the telescope, such as may be supposed to be produced by flexure of the support of the prism.

It will be seen from this brief summary of M. Loewy's proposal that the investigation of the elements of refraction may thus be made to depend entirely on easy differential measures, which can be rapidly made with practical freedom from all systematic errors except those which may be due to atmospheric chromatic dispersion.

Having considered the practical details which are necessary for the most perfect realisation of these ideas, I am led to propose a few modifications of M. Loewy's apparatus, which promise to increase the ease of working as well as the general accuracy and utility of the method.

1. Instead of a fixed telescope-tube with rotation of the prism in front of the object-glass, let the prism be attached rigidly to the cell or mounting of the object-glass, the latter attach rigidly to the tube, set the webs of the spider-line micrometer permanently parallel to the line of intersection of the reflecting surfaces of the prism, and give rotation to the whole tube round its own axis, by placing it in a cradle attached to the Declination axis, after the manner of the tube of a modern heliometer. A position-circle attached to the tube, and read by verniers attached to the cradle, should also be provided. By these means a sufficiently rigid relation between the prism and spider-line micrometer would be preserved, and the necessity for computing the setting of the direction of measurement for the spider-line micrometer would be entirely avoided.

To find the two stars it would only be necessary to direct the tube, by the R.A. and Declination Circles, to the hour-angle and Declination of the middle point between the stars, and to set the position-circle to the angle which the great circle joining the two stars makes with a circle of Declination passing through the middle point between the stars. Both stars would then be seen in the field of view, and by small movements of the position-circle and of the slow-motion handles in R.A. and Declination, these images may be brought between the fixed position-angle wires (which mark the direction of measurement), and the measures can then be made by the movable wires with the greatest facility. The resulting measures are independent of any possible small motion of the prism relative to the axis of the telescope, and of any errors in the adjustment of the equatorial stand. The altitude of the stars can be deduced, with all necessary accuracy, by noting the time of each observation.

Convenient and simple as this observation may appear, it is subject to the objection that angles exceeding ten minutes of arc

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cannot be measured by the spider-line micrometer with sufficient accuracy, when it is necessary that both objects be simultaneously bisected. The choice of objects for observation is thus limited to pairs of stars whose distance is equal to twice the angle of the prism $\pm 10'$ of arc. This objection could be overcome by the use of two eyepieces, or still better by the device of Alvan Clark, which, "by a convenient arrangement of prisms enables both webs, though separated one degree in a large telescope, to be seen in the same eyepiece." Unfortunately the latter arrangement is not described in detail by its author, and is said to be, as yet, somewhat troublesome to arrange previous to measurement, though, when arranged, it gives very good results.

2. An investigation of the elements of refraction on the preceding plan involves the construction of a complete special apparatus, but it becomes comparatively easy to adapt a modern heliometer to the purpose. It is only necessary to mount the prism in front of the object-glass, with the line of intersection of its reflecting planes at right-angles to the line of section of the segments of the object-glass and to the axis of the heliometer.

Observations can then be made by bringing the two images into coincidence in the centre of the field by symmetrical movements of the segments of the object-glass, as in the ordinary process of measurement with a heliometer. Unfortunately, by this method, angles smaller than twice the angle of the prism cannot be satisfactorily measured, but the large range of angle embraced by the heliometer makes this of little consequence. The chief drawback to the method is that when the objects do not differ much from 90° apart (that is, when the optical centres of the segments are nearly in coincidence) only one quarter of the whole area of the object-glass is available for seeing each star, and in order to give symmetry to the images at all distances it would probably be necessary to place diaphragms, shaped thus (fig. 2), on both segments of the object-glass.

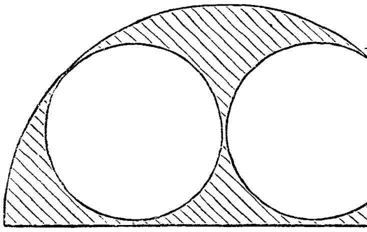

Fig 2

Thus with a heliometer object-glass of 4 inches aperture, the available aperture for seeing each star would correspond with that of an object-glass but little over $1\frac{1}{2}$ inch aperture. This, however, would permit accurate observation of stars to the 6th magnitude, and an ample selection of pairs of such stars would be available within the range of 88° and 90° in distance.

Royal Observatory, Cape of Good Hope:
1886, *February* 26.

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Note on the Observations for Coincidence of the Collimators through the Cube of the Transit Circle at the Royal Observatory, Greenwich. By H. H. Turner, B.A., B.Sc.

For some time after the erection of this instrument, observations for coincidence of the Collimators could only be made after first raising the instrument, so that the view of one Collimator by the other was uninterrupted. In 1866 December, however, the central cube of the Transit Circle was perforated so that when the instrument was placed vertical a view of the South Collimator by the North could be obtained through eight holes of sector form, symmetrical about the common axis of the Collimators. The radial bars separating these sectors were not cut away in the hope of avoiding any serious interference with the rigidity of the cube, although this prevented the use of the central portions of the object-glasses of the Collimators in the observations. It was noticed soon afterwards that there was a small discrepancy between the readings for coincidence of the North Collimator on the South obtained when the Transit Circle was raised as before, and those obtained by this new method of viewing; but Sir George Airy, in commenting on it in his Report to the Board of Visitors in 1868, expressed some scepticism as to the reality of the discrepancy, and was more inclined to attribute the apparent discordance to "an erroneous habit in the application of the eye to the eye-glass, combined with a very small error of focal adjustment." The results of a number of observations in 1869 and 1870 were collected, however, and the mean difference of readings of the micrometer of the North Collimator was found to be $0^{\mathrm{r}}{\cdot}020$ and $0^{\mathrm{r}}{\cdot}024$ respectively, corresponding to $0''{\cdot}48$ and $0''{\cdot}58$. Experiments were made in 1872 November by two observers to test whether the position of the eye made any sensible difference in the reading for coincidence of the Collimators, but no such effect was discernible.

Accordingly from 1874, January 1, the discrepancy was accepted as real, and the reading obtained through the central cube was regarded as erroneous to that extent, owing to some cause not sufficiently explained; a correction of $0^{\mathrm{r}}{\cdot}019$ (equivalent to a difference of $0^{\mathrm{r}}{\cdot}023$ in the reading for coincidence of Collimators) being applied to the concluded reading for line of collimation of the Transit Circle micrometer.

The examination of the results of weekly observations in subsequent years confirmed this value of the correction as sensibly constant.

It still remained, however, to satisfactorily explain the discrepancy, and to determine whether the observations made with the Transit Circle raised had been correctly regarded as the standard. It seems very unlikely that the raising of the instrument produces an actual disturbance of either Collimator, for